Regional Stratification and Shear of the Various Streams Feeding the Philippine Straits

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LONG-TERM GOALS

To provide observations and analysis of the stratification and shear at sub-meso to meso-scales and to regional scales of the various streams that feed into and through the Philippine Archipelago complex; to determine their relationship to the regional ocean and monsoon forcing. These contribute to the "Characterization and Modeling of Archipelago Strait Dynamics" DRI [PhilEx] goal: to enhance our understanding of the oceanographic processes and features arising in and around straits, and improve our capability to predict the inherent spatial and temporal variability of these regions using models and advanced data assimilation techniques.

OBJECTIVES

To resolve the circulation and mixing within the Philippine Archipelago and neighboring seas [South China Sea, Sulu Sea and boundary with the open Pacific Ocean] during opposing monsoons. Features and processes of particular interest are those associated with the interaction of the mean and tidal currents with the strong seasonal forcing at regional and smaller scales, including the effects of the complex topography characteristic, passage contrictions and blocking sills of the Archipelago; the interaction of the interior seas of the Philippine Archipelago [Mindanao and Sibuyan Seas] with the larger scale dynamics; and dense overflow into isolated deep basins.

APPROACH

The stratification and circulation is measured with an array of CTD/Lowered ADCP stations as well by the underway data [notably the hull mounted ADCP, SST/SSS and surface chlorophyll]. These data are integrated with other observational data, including moored instrumentation and model output as needed to meet the DRI objectives. I collaborate with other DRI observationalists: Amy Ffield, Earth and Space Research: LADCP; Pierre Flament, University of Hawaii at Manoa: High frequency radio; Craig Lee, University of Washington: towed vehicles and Gliders; Janet Sprintall, Scripps Institution of Oceanography: ADCP moorings; and Cesar Villanoy and Laura David, both at the Institute of Marine Research at the University of the Philippines.

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WORK COMPLETED

The PhilEx Exploratory Cruise was completed from the R/V Melville 06 June to 03 July 2007, Manila to Manila. Figures 1 and 2 show the track and CTD/LADCP station array. The design of the 2008 [Mindoro Strait] and 2009 [Suraigao Strait] IOP cruises depends to a large measure on the results of the exploratory cruise. The final cruise report and the detailed weekly reports of the Exploratory cruise were distributed to the PhilEx researchers, and posted by the program web site: http://www.satlab.hawaii.edu/onr/mindoro/wiki/index.php?n=Main.HomePage

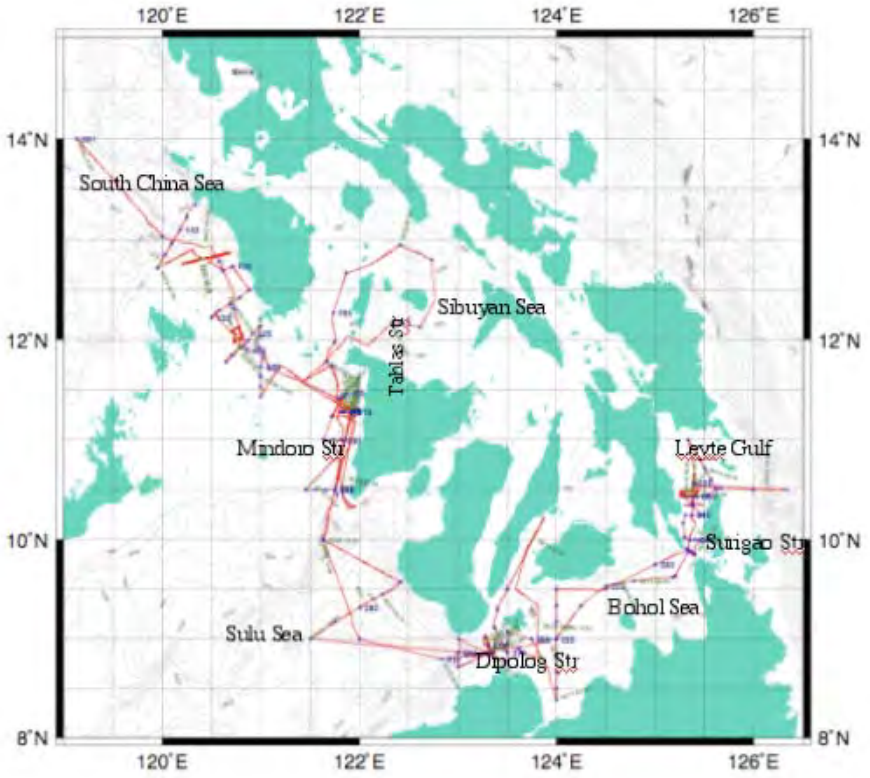

Figure 1. PhilEx Exploratory Cruise Track. The PhilEx Exploratory Cruise was completed from the R/V Melville 06 June to 03 July 2007, Manila to Manila.

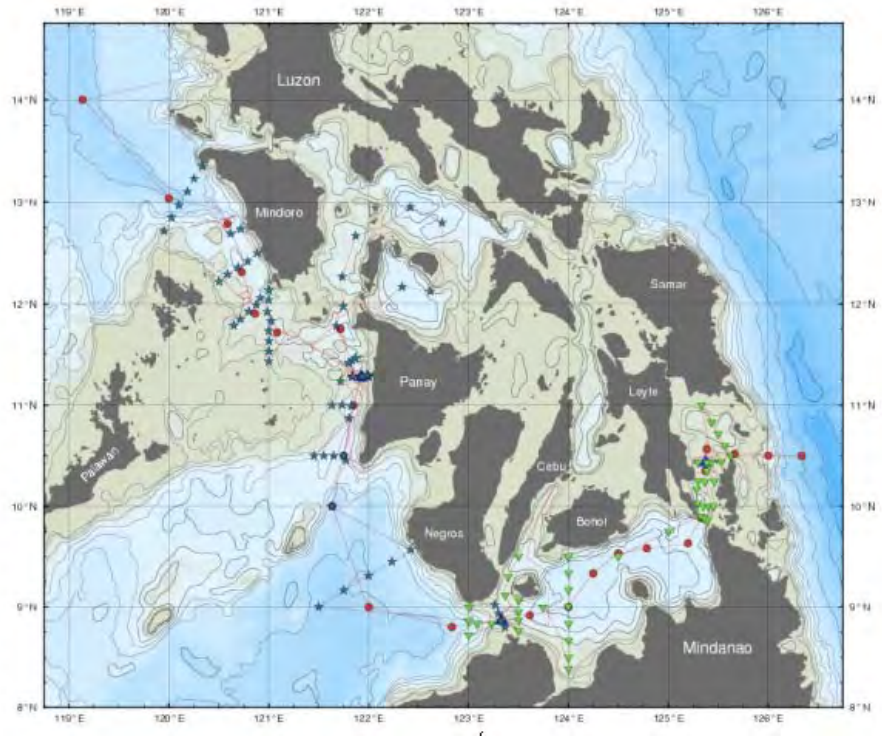

Figure 2. CTD/LADCP array obtained duriung the Exploratory Cruise. The symbols are arranged by time: 6 to 12 June: solid Red circles; 13-18 June: green triangles; 19 June - 2 July: Blue stars. Occasionally stations from different weeks are in same place blurring the symbol shapes. The large Blue triangles show positions of the current measuring [ADCP] moorings.

RESULTS

The exploratory cruise provides much data to enhance our understanding and insight of the oceanography of Philippine waters, as required for planning of the IOP activities in January-March 2008 and January-March 2009. Some key results are:

• Western Pacific water of the upper ~100 m via San Bernandino Strait and ~50 m in Surigao spread into the adjacent Philippine seas with some influence on the Mindoro stratification and circulation, though the dominant forcing within Mindoro Strait has to do with South China Sea and the Sulu Sea interaction via Mindoro north and south [Panay] segments, with some contribution from the Tablas Strait, which together representing complicated trio of straits joined at the small central Maniquin Sea.

• Estuarine type circulation is characteristic of the upper 300 m Mindanao {Bohol) Sea, the Pacific surface westward flow being the “river”, the Sulu Sea being the “coastal ocean”. There appears to be a double Estuarine cells, with the surface one driven by the Pacific surface layer and the deeper one driven by the dense water overflow of Sulu Sea water into the depths of the Mindanao Sea via the Dipolog Strait [western entrance to the Mindanao Sea]

• Overflow of relatively dense water into the confines of the Sulu Sea, Mindanao Sea and Sibuyan Sea are energetic features of the circulation and shape the stratification below associated sill depths. The

overflow into the Sulu Sea by way of the Panay Strait [southern member of the Mindoro Strait] is particularly active, showing clear signs of tidal modulations [Fig. 3]. The flow within the benthic layer, lower 100 m, is directed towards the southeast, the along-channel direction. The bottom intensified flow spills into the depths of the Sulu Sea. Benthic layer speeds of ~ 2kts are measured; we estimate spillover transport of 0.25 Sv and a residence time for the deep Sulu Sea of ~50 years. The deep isolated Sulu Sea may experience effects of geothermal heating, and perhaps ventilation timing linked to El Niño episodes.

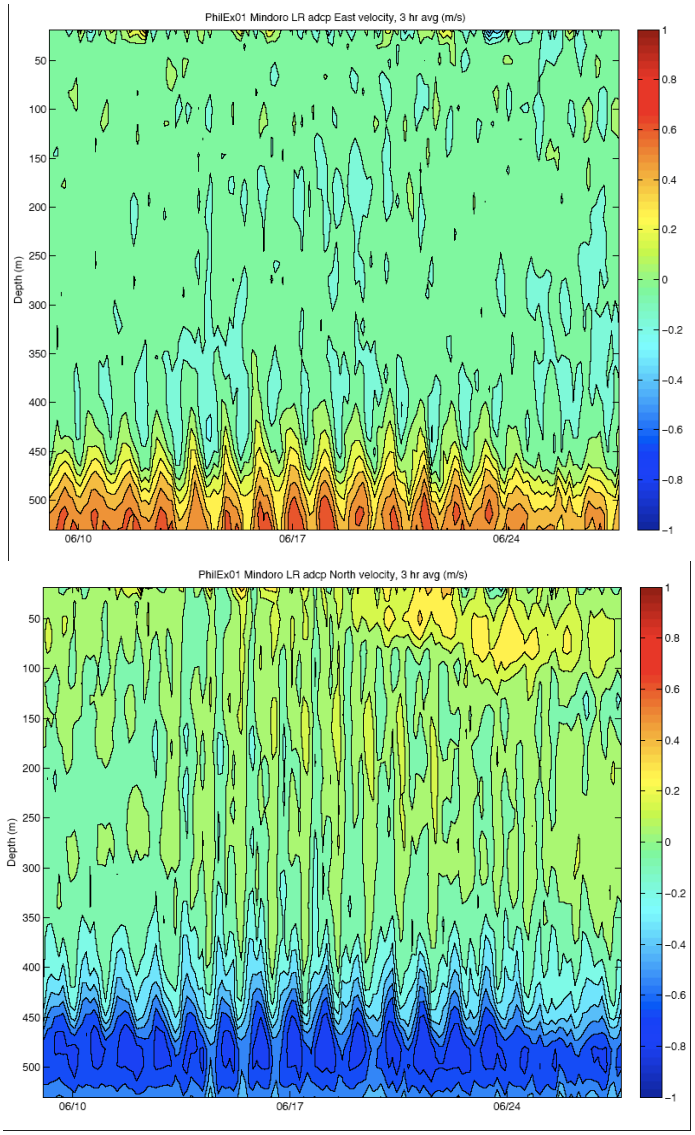

Figure 3. Zonal [upper panel] and meridional [lower panel] speeds recorded by the Mindoro ADCP mooring 11° 16.646' N 121° 55.456' E. Note the vigor of the benthic layer current.

• Tides are very much in evidence in the circulation and overflow throughout the Philippine waters, but they are particulaly dominant within the Surigao Strait, shaping the estuarine circulation pattern of Mindanao Sea, and the characteristics of the Pacific inflow.

• The flow within the Mindoro Strait is western intensified [Fig. 4]. The numerous reefs in Mindoro north may act as “stirring rods” creating a field of eddies and wake phenomena within the mean flow. The Mindoro circulation in late June differed from that of early June, which may mark the maturing of the summer monsoon regional forcing.

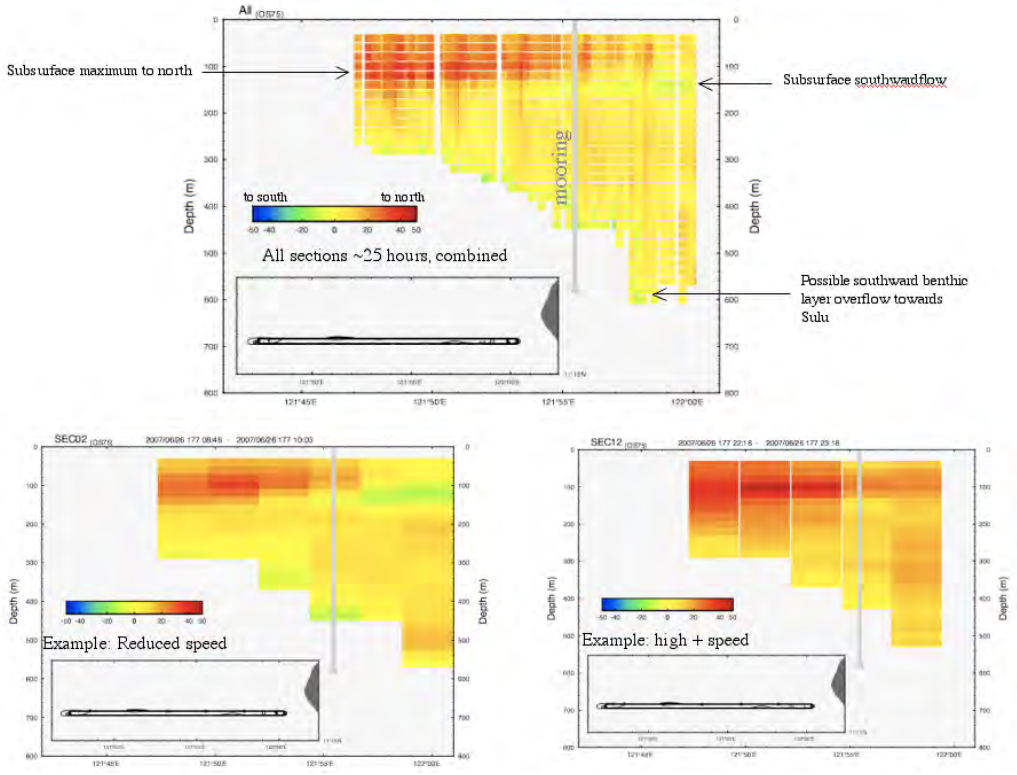

Figure 4. Meridional speeds across the latitude of the Mindoro south mooring, 11°17’N. Upper panel is an ensemble of all of the 18 sections over 25 hours. The lower panels are examples of sections that show weaker [left] and stronger [right] northward flow.

• During the Exploratory cruise we experienced very low wind and waves, generally ~10 kts though winds of slightly over 20 kts were more common in the northern Mindoro Strait at the end of June. Thus we observed ocean processes under minimal local wind action, exposing ocean processes driven by tides and remote forcing from the surrounding large water bodies. The winter season timing of the IOP will see much larger wind stress curl conditions.

• Schematics of the circulation with the Mindanao Sea and Mindoro Straits are given as figures 5 and 6.

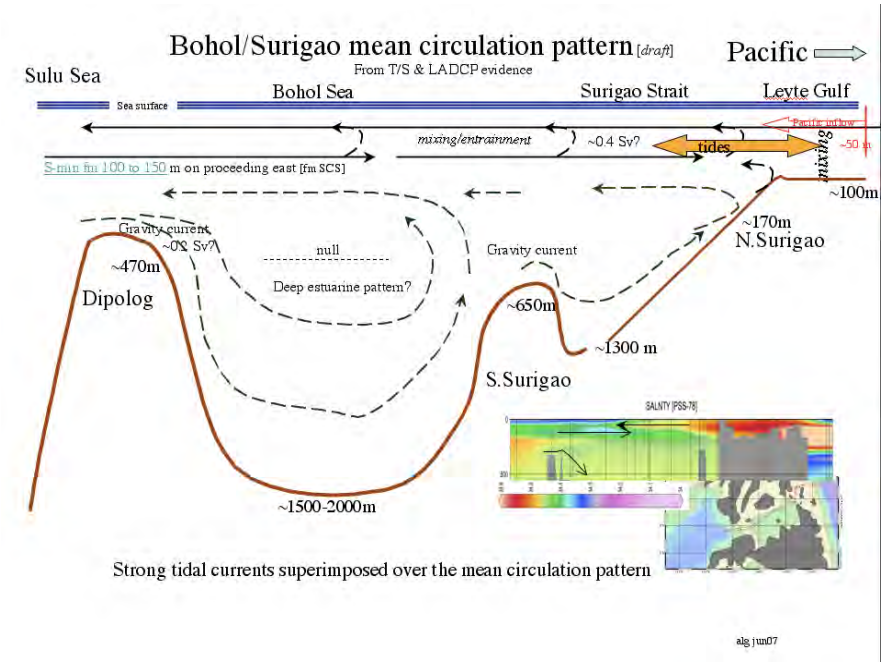

Figure 5. Schematic representation of the Mindaneo [Bohol] Sea mean circulation pattern as determined by the observed thermohaline stratification and shear.

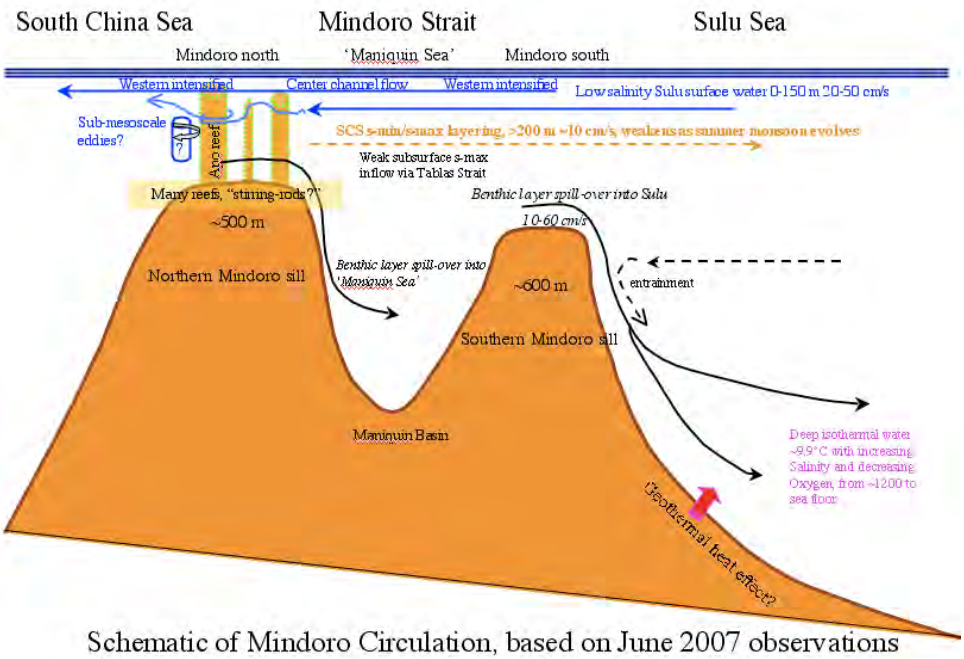

Figure 6. Mindoro Strait Schematic of along-axis summer monsoon circulation and stratification, as determined by the observed thermohaline stratifcation and shear.

IMPACT/APPLICATIONS

The exploratory cruise provides information for planning of the PhilEx IOP activities in January-March 2008 [Mindoro Strait region] and January-March 2009 [Surigao Strait region]. The resultant numerical model, honed by observations, and the enhanced understanding of the oceanography of the Philippine waters to be produced by the PhilEx program will have a multitude of applications in managing marine resources and the marine environment of the Philippines, as well as for issues of marine safety and prediction of marine pollution dispersion.

TRANSITIONS

None

RELATED PROJECTS

None

REFERENCES

None

PUBLICATIONS

None

PATENTS

None